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Original Paper

Exploration of CDIO Graduate Education Mode Based on the Integration of Industry, Teaching, Competition and Research

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Abstract

Aiming at the current phenomenon of disconnection between theory and practice in graduate teaching, a CDIO graduate education model based on the integration of industry-teaching-race-research is proposed in the paper, which tries to integrate industry-teaching-race-research and improve students' innovation and application ability through various teaching modes. The focus of the reform is embodied in the school-enterprise cooperation, which closely associates the school and the enterprise through the project, and the two of them explore a new type of teaching mode at the teaching level, complete the restructuring of the teaching content, and implement the four levels of assessment for graduate students, namely, the basic knowledge of engineering, the individual ability, the interpersonal team ability, and the ability of the engineering system. Through the analysis of the survey results, the reform has achieved better results in the training of graduate students, which can effectively improve the quality of teaching.

Keywords

CDIO, teaching reform, advanced software engineering, university-enterprise cooperation

Introductory

Graduate education is an important component of the higher education system, playing an indispensable role in the entire university education, mainly reflected in national macro strategy, local economic development, and the cultivation of innovative talents. Postgraduate training mode should follow the following key points, in the new era of new engineering background, focus on cultivating

innovative talents with comprehensive ability, cultivation methods and means should be oriented to the development of the local economy, to serve the real economy as the goal, to promote the industrial upgrading of the modern enterprise as a hand, the implementation of a comprehensive and sustainable talent training strategy, all-round construction of the industry-teaching, race and research integration teaching mode reform (Wang, 2024). The computer science and technology program in colleges and universities is an important carrier for cultivating students in line with the needs of the computer industry. Through exploring the educational model of integration of industry, education, race and research, we try to find solutions to the key and difficult problems in graduate education; through the collaborative construction of schools and enterprises, we discover the strengths of the students, enhance the enthusiasm for learning, develop students' thinking, and continue to strengthen their professionalism and professional self-confidence. Meanwhile, the follow-up work of this exploration hopes to complete the co-construction with other disciplines to expand the research ideas to more fields in order to enhance the comprehensive ability of our students (Li, Xiong, & Jiang, 2021).

1. Exploration and Problems of the New Teaching Model

1.1 CDIO Teaching Model

CDIO engineering education model is the latest achievement of international engineering education reform in recent years. CDIO stands for Conceive, Design, Implement and Operate, which enhances the practical ability of students with engineering thinking, tries to integrate students into the engineering reality of enterprises, and divides the ability of students into four levels, namely, basic knowledge of engineering, personal ability, interpersonal teamwork and engineering system ability, and then comprehensively evaluates whether the students have achieved the predetermined goals. In the talent cultivation mode, the project-driven method is adopted, and the COIO project is divided into three levels according to the scale: (1) covering the content and experiments of the majority of the major courses of the specialty; (2) including the content and experiments of the core courses of the specialty; and (3) including the content and experiments of some of the courses of the specialty.

1.2 Industry, Teaching, Competition and Research Integration Teaching Mode

The teaching model of "industry-teaching-competition-research" integration pursues the application of talents. That is to say, the formulation of teaching plan refers to the industrial development strategy, the development of the industry and enterprise is closely related to the daily teaching, and the students are employed upon graduation, so as to complete the marketization of talent training. In teaching, "production, education, competition and research" are fully integrated into the pre-course, class and post-course, so as to promote research by teaching, practice by competition, and promote production by research. The teaching mode will form a new thinking, new habits, new attitudes among students, and is intended to reshape students' learning styles to be able to learn with innovative thinking, with the teaching content and methodology based on the practical ability as the test standard, focusing on the cultivation of students' innovativeness, and with a clearer goal of future employment. The model

actively explore the development path of the industry and enterprises, teachers and enterprise engineers go out and invite in, and reciprocal cooperation with enterprises, talent cultivation hit the needs of enterprises, and inject new vitality into the industry.

1.3 The Dilemma of Professional Development

Usually the graduate school of colleges and universities are equipped with computer science and technology majors, for some of the second colleges and universities, the construction of the specialty often has a certain degree of convergence, the curriculum system is not perfect, it is difficult to reflect their own characteristics. The curriculum design of some colleges and universities is not close to the advantages of the industry in the region, can not hit the pain points of enterprises, and can not effectively provide professional talents for enterprises (Meng, Sun, & Wang, 2021; Li, X. L., & Li, L., 2024). In designing the curriculum system, some institutions have introduced some relevant knowledge that is close to the local industry, but the curriculum design lacks systematicity and poor back-and-forth articulation, and they have even set up the main courses as elective courses. After studying such courses, students stay at the cognitive level and do not have a deep experience of certain specialized knowledge, and after employment, they will suffer from a knowledge gap or a lack of basic knowledge. In the professional construction, the teacher is an important factor to improve the quality of teaching, and a considerable part of full-time teachers come from college graduates, i.e., they do not have practical experience in the enterprise and lack of industry literacy at the micro level, so they can't give students a good boost in terms of practical ability. Such teachers can give students professional guidance in academics, but can not complete the deep integration of theory and practice, practitioners can only come from the network or books, the knowledge taught is more vague, but the practice of anti-practice refinement, the case is likely to be unable to match with the industry perception. The model of industry-teaching integration is an effective path for professional development, from which both students and teachers can benefit, as enterprises can complete the construction of training bases on campus, students can participate in production internships in enterprises, and teachers can further their education in the curriculum (Zeng, 2024). However, there are some problems with this type of school-enterprise cooperation and co-construction, such as the lack of synchronization between the cooperative enterprises and the overall training program of the college, or the uneven benefits of school-enterprise cooperation without the cornerstone of sustainable development. Another mode is to hire external enterprise personnel to teach in schools, but the cooperation process will have the problem of setting up classes according to people and unclear training objectives. Therefore, the mode of school-enterprise cooperation should be studied in depth to find a mutually beneficial access point for sustainable development.

2. Construction of Practice Bases for School-Enterprise Cooperation

2.1 School-Enterprise Co-construction Model

The purpose of CDIO engineering education model is to cultivate innovative and application-oriented

talents who can adapt to the needs of the industry and enterprises upon graduation. The practice teaching base of industry-teaching integration is built by both the university and the enterprise, which integrates the cultivation of postgraduates' practical ability, completes the unification of the theory and practice of talents, and improves the comprehensive quality of the students. The construction of the base should reflect the complementary nature of the resources of all parties and give full play to the strengths of all parties, and the university should act as the management of the base (Zhang & Cai, 2022). The professional talent training program should be industry forward-looking, give full play to the ability to collect information, analyze the needs of enterprises, and formulate a reasonable graduate talent training plan in combination with the characteristics of the specialty. In terms of theory, the establishment of advanced theoretical knowledge system, focusing on the construction of basic disciplines, and at the same time to reflect the industry attributes, focusing on future trends; in terms of practical ability, student-oriented, focusing on cultivating postgraduate students' practical ability, examining the ability to apply knowledge, the ability to innovate knowledge, as well as the ability to collaborate, and at the same time also focusing on postgraduate students' innovative thinking cultivation, reflecting the spirit of scientific research, and being able to think and solve problems independently (Wei, Hu, & Zhang, 2024).

2.2 Course Settings

The university and enterprises jointly send personnel to participate in the formulation and implementation of the postgraduate training plan, both sides refer to the syllabus and combine the characteristics of the industry to formulate the program with innovative and scientific research attributes, organize the postgraduates to combine the research direction with the reality of the enterprises, and complete the scientific research work by using the actual projects. The reform of the curriculum should be adapted to the integration of production, education, competition and research, and the projects under construction in enterprises should be introduced into the school-enterprise cooperation program as a whole or disassembled partly, so as to guide postgraduates to conduct scientific research training by projects, so that the scientific research projects will have a certain focus, and the dissertation research will not be divorced from the reality, and then complete the scientific and technological innovation. This kind of scientific research training not only promotes production and research, but also reorganizes the direction of discipline construction, thus completing the deep integration of industry, academia and research.

2.3 Pattern Exploration

The School-enterprise cooperation graduate training model can develop co-built high-quality courses, innovation and entrepreneurship programs, as well as engineer-teacher role swapping. It is necessary to pay attention to the exploration of in-class and out-of-class teaching of graduate students, carry out the new classroom teaching mode, introduce the engineers in the enterprises into the daily teaching, and bring the actual cases of the enterprises into the campus, make clear the demand orientation of the engineering projects, carry out the purposeful teaching in the classroom, and then extend it to the

extracurricular practice, in order to enhance the innovative thinking and engineering thinking of the graduate students.

Actively carry out industrial elements into the classroom activities, synergistically develop a new education model, and form a new cooperation mechanism of project engineering, new type of talents, and fast employment. In terms of graduate student tutors, explore the implementation of dual tutor strategy, i.e., on-campus tutors and off-campus tutors in parallel, unblocking the passage barriers between theory and practice, and teachers and students attacking the actual problems of the industry and enterprises. School-enterprise cooperation is not only limited to the student side, teachers can also go deep into the enterprise, stationed in the enterprise in the role of observer or technical guidance, participate in the enterprise's project, can carry out joint declaration of the project, and apply some of the results with the teaching and research, to form a benign interaction between the school-enterprise cooperation, to complete the project co-construction of the innovative plan.

3. Reform of CDIO Teaching Mode by Integration of Industry, Teaching, Competition and Research

To explore the postgraduate training mechanism of industry-teaching-competition-research integration, to ensure the healthy development of diversified integration from the institutional system, and to complete the reconstruction of the whole teaching system, the advantages of the diversified integration mechanism should be analyzed from the theoretical high level, to play the advantages of the tripartite combination of the government, the enterprises and the schools, to mobilize the talents and the resources in a unified way, to listen to the opinions of people from all parties extensively, to maximize the utilization of the educational resources, and to construct the comprehensive new mode of postgraduates' training.

3.1 Analysis of Blended Learning

The standardization of teaching process plays an important role in the establishment of postgraduate training system, how to rationally combine teachers, students, engineers, information technology resources, learning modes and evaluation system, and scientifically and efficiently design each teaching link and each course content, including before, during and after class. In the mixed teaching mode, the content ratio of online transmission should be no less than 30%, which is a process control and is conducive to the improvement of students' learning initiative under the supervision of teachers. In the design of the course, it is necessary to analyze the course in all aspects, including the current situation of the course, the target of instruction and the design of the situation. In the overall design of the course, it is necessary to pay attention to the introductory knowledge, how the units are divided, and transmit the relevant information to the teaching platform, and set the content of each unit, including the chapter introduction, the chapter objectives, the chapter auxiliary materials, the chapter activities and evaluation.

3.2 Teaching and Learning Content Reorganization

Postgraduate courses are more theoretical, especially academic master's degree, which emphasizes on cultivating students' research ability, and the courses are mainly theoretical, focusing on cultivating students' theoretical literacy and scientific research ability. In teaching practice, focusing on the penetration of application ability can improve students' interest in learning, and for this reason, different kinds of project cases are designed to promote teaching in the course in combination with students' characteristics.

3.2.1 Pre-class

Sort out the knowledge points of the course and break down the teaching content into different types of projects, which can be specifically categorized into basic projects, advanced projects, and extended projects. Among them, the basic project chooses some classic algorithms as the entry point, and is completed by students teaming up and collaborating with each other; Progressive projects, relying on a team of tutors, including teachers, engineers and outstanding graduates, insist on linking theory with practice, insisting on teaching and scientific research, insisting on practice to promote scientific research, building postgraduate study groups, and advancing projects with industry development trends selected in enterprises; Expanded projects, with reference to this year's national competition projects of all kinds of mainstream computer competitions to design cases, intends to broaden students' horizons, to find out the development trend of the industry, to complete the daily projects with the thinking of the competition, to closely link the research work with the competition, and then actively participate in all kinds of competitions to enhance the practical ability.

3.2.2 In Class

The key content has been uploaded to the teaching platform before the class, and the teaching in the class is project-driven. For basic projects, students' interest groups can carry out project projection and mutual evaluation between groups or students. This type of project is more basic and mainly examines students' ability to master basic knowledge and basic application ability; Expansion projects, using the form of group discussion, the complexity of such projects have a certain degree of enhancement, the teacher needs to be actively involved in the discussion, and at the same time can carry out online meetings to invite the participation of enterprise engineers to form a kind of multi-role interaction of the project team, through which the students' mastery of theoretical knowledge can be more in-depth; Expansion type project, in class to do analysis of recent years the national major A class computer competition award-winning works, study the technology applied in the works, and cross-comparison with the research project in progress, to find the technical correlation, and ultimately improve the enterprise project.

3.2.3 After Class

For the three different types of projects, analyze the commonalities and their respective characteristics, teachers should regularly communicate with each group, and regularly organize the sharing of resources between the various groups, the progress of technology is not only reflected in the group, but

also in the system between the groups, the three types of projects is a hierarchical progression of the relationship between the completion of the project of the various groups is also a step-by-step process, can be converted to the internal flexibility, in order to better complete the practice of teaching.

3.3 Overall Training Program Design

Under the premise of integrating project-driven, flipped classroom, and online and offline multiple teaching modes, this project develops a teaching reform training program from three aspects: framework design, reform content, and evaluation system. Strive for comprehensive control from top-level design to specific implementation, and ultimately evaluation, to implement curriculum reform in practice, seize the starting point of reform, integrate students, teachers, and industry experts, and do a good job in building a resource sharing platform. The relevant table is as follows:

Table 1. Framework Design

content	details
master plan	Serving industries and enterprises
	Cultivate innovative and applied talents
	Research new technologies
Ability development	Theoretical literacy
	Practical operation ability
	Ability to comprehensively solve practical problems
Plan formulation	Construction of theoretical knowledge system
	Cultivation of scientific research ability
	Innovative application capability

Table 2. Reform Content

content	details
Course content	Basic theoretical knowledge
	Practical ability cultivation
	Industry capability development
Practical ability	Project requirements
	The relationship between theory and practice
	Ability to comprehensively solve practical problems
Essay literacy	Data collection
	Paper writing
	Patent application

Table 3. Evaluation System

content	details
School enterprise collaboration	Establish a basic school enterprise cooperation mechanism
	Project Promotion
Talent pool	Establish a talent exchange resource pool
	Personnel communication and assessment
	Excitation mechanism
	Collaborative communication
Graduate evaluation	Theoretical knowledge evaluation
	Actual operational capability evaluation
	Innovation capability evaluation

4. Analysis of the Effect of Teaching Reform

4.1 Overall Idea

The teaching reform project relies on Advanced Software Engineering, a course that enables students to understand and learn about various types of mainstream software engineering, and to further their understanding of advanced software engineering processes, methods, tools and new software engineering technologies. Assessment point: learn the core techniques and methods of process-oriented software engineering, object-oriented software engineering, component-oriented software engineering, Agent-oriented software engineering and new software technologies. The evaluation system of the course concentrates on the idea of CDIO, that is to say, it highlights the thinking mode of engineering, the evaluation process should give more consideration to applicability, innovativeness and synergy, the focus of evaluation examines the degree of participation, and the evaluation index pays attention to the difference. Therefore, formative evaluation indicators and contents are formulated, aiming at an evaluation that accurately and objectively reflects students' behaviors, attitudes and learning outcomes in the learning process (including individual independent learning and team research learning outcomes), as well as the examination of students' non-intellectual factors such as emotion and morality, as shown in Table 1.

The program assessment is divided into 4 parts, corresponding to the relevant knowledge points, and the rules are shown in the table below:

Table 4. Curriculum Evaluation Standards

Evaluation project	Capability evaluation	Assessment method	Specific gravity (%)
Pre-class	Autonomous learning	terms of	10

		reference	
In class	Proficiency in knowledge	Flipped Classroom	5
	Collaborative communication skills	Student interaction	5
	Practical operation	Group communication	5
After class	Scientific research innovation	Teacher involvement	10
	Engineering application	Inter group communication	5
Comprehensive evaluation	Application and innovation capabilities	Paper writing	60
	Expanding ability	Participate in the competition	

4.2 Effectiveness Analysis

The teaching reform of this course mainly cultivates students' ability to apply professional foundation, thinking and logic analysis ability, teamwork ability and innovation and entrepreneurship ability. The subject is applied to the graduate school of computer science and technology, with a total of 60 students, and compared with the students of the same major at the previous level who did not carry out the curriculum reform, through the questionnaire as well as the course assessment, the above four abilities are analyzed, as shown in Figure 1.

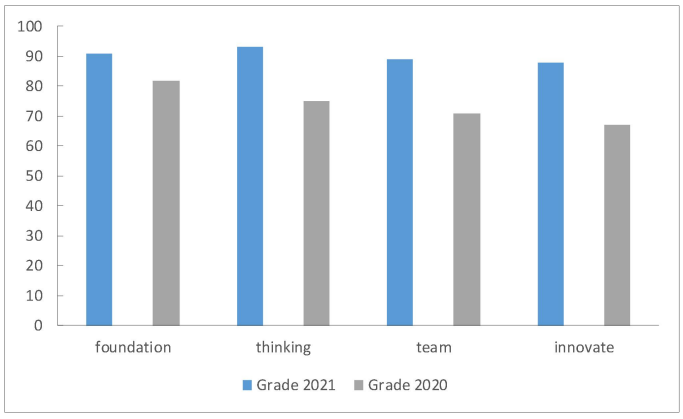

Figure 1. Comparison Chart before and after Curriculum Reform

Through Figure 1, it was found that the teaching effect was significantly improved after completing the

teaching reform, and the four dimensions of the test were improved by 11%, 24%, 25%, and 31% respectively compared with the time when no reform was carried out, in which the limited improvement in the basic aspect belonged to the normal category, and the improvement in the aspect of innovativeness was the most obvious, and the teamwork was the second one, which indicated that the graduate student's scientific research ability was substantially enhanced, and the project progressed in accordance with the expectation, and it was worth to be further popularized.

5. Conclusion

In response to the many problems in graduate teaching, this teaching reform proposes the CDIO model, attempting to integrate industry, education, competition, and research together to solve the difficulties of professional development. Overall set the school-enterprise cooperation model, establish a talent resource pool, reasonably match students, teachers and industry experts, and complete the construction of the curriculum system. Project-driven, flipped classroom and competition training are adopted before, during and after class respectively, aiming at enhancing students' innovative application ability, moving the content from class to class, and applying theoretical knowledge to practice in an attempt to cultivate talents in line with the COIO model. Through investigation and analysis, the teaching program of the new reform plan was developed, and the test results showed that the reform was effective.

References

Li, X. L., & Li, L. (2024). Exploration and Practice of Advanced Computer Network Course Construction. *Software Guide*, *23*(02), 177-181.

Li, Y., Xiong, A. P., & Jiang, Y. (2021). Exploration of Teaching Construction of Engineering Ethics Course for Graduate Students majoring in Computer Science. *Journal of Higher Education*, *7*(34), 83-87.

Meng, F. Q., Sun, H. C., & Wang, J. D. (2021). Exploration of Teaching Reform in the "Data Mining" Course for New Engineering Graduate Students. *Heilongjiang Education (Higher Education Research and Evaluation)*, *2021*(04), 54-55.

Wang, K. X. (2024). Teaching Reform and Practice of Neural Network Courses for Cultivating Graduate Innovation Ability. *Journal of Xinzhou Normal University*, *40*(02), 44-50.

Wei, L., Hu, Y. H., & Zhang, Q. B. (2024). Exploration and Practice of Talent Cultivation in Software Engineering from the Perspective of "Integration of Specialization and Innovation". *Research and Practice of Innovation and Entrepreneurship Theory*, *7*(03), 101-105.

Zeng, X. (2024). Innovative reform strategy of Chinese language and literature education practice for college students based on information fusion technology. Applied Mathematics and Nonlinear Sciences, *9*(1), 1-17. https://doi.org/10.2478/amns.2023.1.00236

Zhang, L., & Cai, Y. (2022). *Reform of Computer Science and Technology Professional Talent Training Model Based on OBE Concept - Taking Chongqing College of Mobile Telecommunications as an*

Example. Proceedings - 2022 International Symposium on Advances in Informatics, Frankfurt, Germany, 458-461. https://doi.org/10.1109/ISAIEE57420.2022.00101